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VEHICLE AIR EMISSIONS INVENTORY

NORTH-SOUTH SECTION

RED HILL CREEK EXPRESSWAY

HAMILTON, ONTARIO

RWDI

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VEHICLE AIR EMISSIONS INVENTORY
NORTH-SOUTH SECTION
RED HILL CREEK EXPRESSWAY
HAMILTON, ONTARIO

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Companion Studies: Air Quality Assessment

Thermal Dynamics Assessment

Traffic Noise Impact Assessment

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TABLE OF CONTENTS

Page No.

1. INTRODUCTION 1

1.1 Key Findings 1

2. CONTAMINANTS OF CONCERN FROM VEHICLE EMISSIONS 2

3. VEHICLE EMISSIONS INTO THE HAMILTON AIRSHED 3

4. SINGLE VEHICLE MOVEMENTS 5

4.1 Scenario 1: Travel Via RHCE Versus Centennial Parkway 6

4.2 Scenario 2: Travel Via RHCE Versus Highway 403/QEW 7

5. CONCLUSIONS 9

6. REFERENCES 10

1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) was retained by the Regional Municipality of Hamilton-Wentworth (Region) to conduct an air emissions inventory of automobile emissions within the Hamilton region airshed, as part of the Impact Assessment and Design Process (IADP) for the Red Hill Creek Expressway (RHCE) North-South section development.

This study characterizes the relative effects of the operation of the RHCE on the air quality within the Hamilton region by focussing on vehicular emissions as they relate to travel patterns, based on analyses of:

a) the results of the Hamilton-Wentworth Air Quality Initiative (HAQI) findings as they relate to the impact of operation of the RHCE on air quality within the Hamilton airshed [1]; and

b) the impact of the expressway on local emissions within the regional airshed based on two examples of single vehicle movements.

1.1 Key Findings

The key findings of this study are:

- The Red Hill Creek Expressway, in conjunction with other planned roadway improvements, is expected to result in a net decrease in emissions of some pollutants from vehicles (cars) travelling in the Region. Based on a Year 2021 morning "rush hour" period, net reductions of 3 to 16% in emissions of some pollutants were predicted.

- The Red Hill Creek Expressway will result in a net decrease of some emissions from individual vehicles travelling throughout the Region, as shown by: 1) vehicles travelling via the RHCE and "Linc" versus the Queen Elizabeth Way (QEW) and Highway 403, as well as 2) vehicles using the RHCE North-South section versus Centennial Parkway.

2. CONTAMINANTS OF CONCERN FROM VEHICLE EMISSIONS

The major pollutants of concern which are related to vehicular traffic include carbon monoxide (CO), nitrogen oxides (NO_X), hydrocarbons (HC) and particulate matter (PM). Hydrocarbon emissions include volatile organic compounds (VOCs) of which there are several species in gasoline, and include toxic compounds such as benzene and polycyclic aromatic hydrocarbons (PAHs). CO, NO_X, and HC are important combustion by-products from vehicular traffic.

The emission rates of these contaminants in an individual vehicle vary with a number of factors such as engine load and temperature, air temperature and the fuel/air ratio. In general, HC and CO emissions are highest while idling, and decrease with increasing vehicle speed. NO_X emissions increase with increasing speeds above 90 km/h. PM emissions from vehicles are primarily the result of wheel-roadway interaction, rather than vehicle tailpipe emissions, and therefore tend to increase with increasing vehicle speed [2]. Emission rates of these compounds can be further affected by the use of emissions control technology (e.g., catalytic convertors) the age and condition of the vehicle, and the type of fuel used (gasoline, propane, natural gas or diesel).

The Ontario Ministry of the Environment has established ambient air quality criteria for a number of the pollutants from vehicular emissions, including CO, NO_2, and PM_{10} (the inhalable fraction of PM dust). An assessment of air quality impacts from the operation of the RHCE North-South Section, including predicted worst-case concentrations at receptors of concern, has been conducted in another RWDI study as part of the IADP process [3].

3. VEHICLE EMISSIONS INTO THE HAMILTON AIRSHED

The effect of the proposed RHCE (amongst other planned roadway improvements in the Region) on vehicle emissions within the regional airshed was studied previously as part of the Hamilton-Wentworth Air Quality Initiative (HAQI) [1, 4, 5].

The HAQI study simulated the air quality impact of road traffic using the Integrated Model of Urban Land-use, Transportation, and Environmental Analysis (IMULATE), developed at McMaster University. The IMULATE model estimates total emissions of HC, CO, and NO_X from vehicles (automobiles only) within the Hamilton-Wentworth region during morning peak "rush hour" periods. Model inputs included spatial projections of population growth, employment, household structure, and transportation infrastructure provided by the Regional Municipality of Hamilton-Wentworth. A key feature of this transportation planning model is its ability to model the effects of traffic congestion [5]. Please note that PM emissions were not included in the IMULATE analysis.

Different future scenarios were developed to understand the impact of vehicle traffic on the future air quality of the region, by examining emissions during peak "rush hour" periods. Some results of their study that are of particular interest in understanding the air quality impact of the RHCE are presented in Table 1. Note that the data presented are for a single morning "rush hour" period.

Table 1: Summary of Airborne Emissions for Typical Morning "Rush Hour" Period [1, 5]

Scenario	Vehicle Kilometres Travelled (km)	Average Congested Speed (km/h)	Emissions of HC (kg)	Emissions of NO_X (kg)	Emissions of CO (kg)
Year 1991 Existing Roadways	797,085	33.28	7,480	6,577	80,983
Year 2021 With Existing Roadways	972,619	30.78	12,136	8,611	132,527
Year 2021 With New Roadways*	995,324	32.68	10,134	8,308	111,022
Percent Change (Year 2021 New Roadways Versus Year 2021 Existing)	2.3%	6.2%	-16.5%	-3.5%	-16.2%

Notes:

* "New Roadways" includes the Red Hill Creek Expressway and proposed bypass of Highway 5 around Waterdown.

– Please note that the IMULATE model results from the HAQI study only considered automobile traffic. As well, the results presented here did not account for reduced vehicular emissions resulting from improved control technologies in newer cars in Year 2021.

It should be emphasized, however, that the above results are representative of morning peak traffic periods only, and that during off-peak hours, emission levels with the new roadways in place may be higher than for the existing base roads [6, 7, 8]. There will be a greater number of discretionary trips during the evening peak "rush hour" period, however the relative change in emission levels is expected to be similar the morning "rush hour" period [7]. The morning and evening peak "rush hour" periods are expected to represent the worst-case scenario from an air quality impact perspective. The two rush hour traffic periods (0700-0900 hours and 1600-1800 hours) typically account for about 30% of daily traffic movements.

The results in Table 1 show that the addition of the RHCE, in conjunction with other planned roadway improvements in the region, will have a positive effect on the air quality of the Hamilton-Wentworth region, through reducing peak emissions of select gaseous pollutants (CO, NO_X and HC) during "rush hour" periods. Although the total vehicle kilometres travelled within the region during peak hours in the year 2021 are expected to increase with the addition of the RHCE, there will be a corresponding decrease in traffic congestion (shown by increasing average congested speeds) and a corresponding decrease in some pollutant emissions.

4. SINGLE VEHICLE MOVEMENTS

The Red Hill Creek Expressway is expected to dramatically change traffic flows within the region. For example, much of the vehicle traffic that currently uses Centennial Parkway (Highway 20) to travel from the Queen Elizabeth Way (QEW) to the top of the Hamilton "mountain" will likely use the RHCE as an alternative route.

Two scenarios were studied by RWDI to illustrate the effect of this alternative roadway on the air quality in the airshed:

a) the difference in emissions for a single vehicle using the Red Hill Creek Expressway versus the same vehicle using the Centennial Parkway to reach areas at the top of Hamilton "mountain"; and

b) the difference in emissions for a single vehicle using the Red Hill Creek Expressway and Lincoln Alexander Expressway ("Linc") versus Highway 403 and the QEW to travel from the southwest portion of the city to the northeast.

Emission rates for an average gasoline-powered car and light truck, and diesel-powered light and heavy trucks were predicted using MOBILE5C, the vehicular emissions model of Environment Canada, based on a year 2010 operating year and worst-case emissions analysis [9]. Emissions are expressed in terms of mass per distance travelled per vehicle. Please see RWDI Report No. 97-207-06GEN, Air Quality Assessment, North-South Section, Red Hill Creek Expressway for further details on MOBILE5C modelling inputs [3].

Table 2 presents the predicted vehicle emission rates used in this analysis.

Table 2: Predicted Vehicle Emission Rates [3]

Pollutant	Vehicle Speed (km/hr)	Emission Rates (g/vehicle/km)			
		Gas Car (LDGV)	Light Duty Gas Truck (LDGT)	Light Duty Diesel Truck (LDDT)	Heavy Duty Diesel Truck (HDDV)
HC	45	1.11	1.55	0.32	0.99
	90	0.75	1.11	0.19	0.59
CO	45	12.33	16.88	0.68	4.87
	90	6.25	9.58	0.48	3.47
NO_X	45	0.93	1.16	0.66	3.86
	90	1.20	1.53	0.93	5.37

Note: vehicle emission rates predicted for 2010 design year under worst-case conditions using MOBILE5C [9].

4.1 Scenario 1: Travel Via RHCE Versus Centennial Parkway

The following assumptions were used in this analysis:

- The vehicle is travelling from the QEW to Mud Street;
- The effects of grade change can be ignored (i.e., they will be similar for both scenarios);
- Vehicles using Centennial Parkway are assumed to travel at an average speed of 45 km/h, to account for congested travel and vehicle acceleration/deceleration at stop lights;
- A posted speed limit of 90 km/h for the RHCE has been used;
- Additional emissions resulting from acceleration and deceleration at stop lights on the Centennial Parkway have not been accounted for; and
- Free flow traffic conditions are assumed on RHCE.

Table 3 presents the results of this analysis:

Table 3: Single Vehicle Emissions, Travel Via Red Hill Creek Expressway Versus Centennial Parkway

Roadway	Pollutant	Trip Emission (g/vehicle)			
		Gas Car (LDGV)	Light Duty Gas Truck (LDGT)	Light Duty Diesel Truck (LDDT)	Heavy Duty Diesel Truck (HDDV)
Red Hill Creek Expressway	HC	5.14	7.63	1.29	4.07
	CO	43.13	66.07	3.30	23.92
	NO_x	8.27	10.55	6.39	37.09
Centennial Parkway	HC	7.45	10.41	2.12	6.66
	CO	82.64	113.11	4.54	32.60
	NO_x	6.20	7.74	4.45	25.85
Percent Change in Emissions	HC	-31%	-27%	-39%	-39%
	CO	-48%	-42%	-27%	-27%
	NO_x	33%	36%	43%	43%

Pollutant emissions from a single vehicle using the north-south portion of the RHCE were predicted to range from 52% to 143% of those using Centennial Parkway. Levels of CO and HC are expected to be much less. This is due to the reduction of emissions due to idling at stop lights or in stop-and-go traffic. Emissions of NO_X may increase because of the increased speed on the RHCE with respect to Centennial Parkway. The net reduction in emissions will likely be larger, as the increase in emissions during acceleration and idling modes were not rigorously accounted for.

4.2 Scenario 2: Travel Via RHCE Versus Highway 403/QEW

The following assumptions were used in this analysis:

- The vehicle is travelling from the southwest of the city to the southeast. Therefore, vehicle traffic has been modelled as travelling from the "Linc"/Highway 403 intersection at Mohawk Road to the Burlington Street and RHCE intersections at the QEW;

- The effects of grade changes have been ignored;

– Posted speed limits of 100 km/h for Highway 403 and the QEW and 90 km/h for RHCE have been used; and

– Free flow traffic conditions are assumed on all roadways.

Table 4 presents the results of this analysis:

Table 4: Single Vehicle Emissions, Travel Via Red Hill Creek Expressway/Lincoln Alexander Expressway ("Linc") Versus QEW/Highway 403

Roadway	Pollutant	Trip Emission (g/vehicle)			
		Gas Car (LDGV)	Light Duty Gas Truck (LDGT)	Light Duty Diesel Truck (LDDT)	Heavy Duty Diesel Truck (HDDV)
RHCE and "Linc"	HC	13.65	20.24	3.41	10.80
	CO	114.39	175.23	8.76	63.45
	NO_x	21.95	27.97	16.94	98.36
QEW/Hwy 403	HC	23.13	33.30	4.92	15.26
	CO	248.85	371.06	14.44	103.84
	NO_x	36.09	47.41	30.51	177.82
Percent Change in Emissions	HC	-41%	-39%	-31%	-29%
	CO	-54%	-53%	-39%	-39%
	NO_x	-39%	-41%	-44%	-45%

Pollutant emissions from a single vehicle using the RHCE were predicted to be 46 % to 71% of those using Highway 403 and the QEW. The decrease in pollutant emissions is primarily due to the decrease in distance travelled (approximately 8 km shorter) and a decrease in speed (primarily for NO_X emissions).

5. CONCLUSIONS

The Red Hill Creek Expressway is expected to have a positive effect on the air quality of the Hamilton airshed and will contribute to a net decrease in emissions of select pollutants from vehicular sources. Based on the findings in a recent major Hamilton-wide air quality study of automobile emissions (HAQI), reductions of 3 to 16% during the future Year 2021 morning "rush hour" period, emissions of some gaseous pollutants were predicted. Although the amount of kilometres travelled by all vehicles within the region during peak hours are expected to increase, this was predicted to be offset by an increase in the congested traffic speed producing a corresponding decrease in pollutant emissions. Only the major combustion byproducts, namely carbon monoxide, oxides of nitrogen, and hydrocarbons were considered in the analysis using the IMULATE traffic planning model.

Based on two modelled scenarios, the Red Hill Creek Expressway is also expected to result in a decrease in trip emissions from individual vehicles travelling via major highways around the region or travelling north-south over the escarpment, through decreased travel distances and increased free flow speeds.

6. REFERENCES

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[6] Personal conversation between Professor P. Kanaroglou, McMaster University and Mr. Scott Penton, RWDI, June 15, 1998.

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